Solving Discrete Multicriteria Optimization Problems in Group Environment

Filip Andonov

New Bulgarian University,
Department of Computer Science, 21 Montevideo str.,
1618 Sofia, Bulgaria
fandonov@nbu.bg

Abstract. This paper aims to present new methods for group decision making that take into account different decision making styles and their implementation in decision making using the Group Multichoice system.

Keywords: decision support systems, group decision support, client-server, multicriteria analysis

1 Introduction

Decision making problems are unformalized or weakly-formalized problems that require a decision maker (DM) in order to be solved. The resulting solutions are subjective, depending on the DM's preferences. Decision making problems are divided into three major classes: multicriteria problems, decision making problems in risk conditions and decision making problems in uncertainty conditions.

Different tasks ranging from planning, management, analysis and control, to transport, education and ecology can be formulated as multicriteria problems. Multicriteria problems are divided in two major classes depending on formal formulation. Multicriteria optimization problems are defined by a finite number of explicitly given functions, which describe an infinite number of alternatives. Multicriteria analysis gives a finite number of alternatives in table form.

In multicriteria analysis problems, a set of criteria are optimized simultaneously in an admissible set of alternatives. Generally, there is no alternative optimal by all criteria (in this case the solution of the problem is trivial). For practical purposes, it is necessary to select only one alternative – with the help of additional information, extracted from the DM. According to the types of information given by the DM the methods are divided into: weighting methods, outranking methods and interactive methods [1].

With the development of information technologies, Internet and electronic communications more attention is paid to group decision making problems (GDMP). They are an extension to existing problems. However, in GDMPs the decision is not made by a single DM but by a group of DMs, often referred to as experts. There are three different approaches, the apriori, aposterior and interactive approach, for aggregating the information provided by the decision makers in GDMP. The methods implementing the apriori approach aggregate

the DM's preferences. It is assumed that the group is working as one entity with one hierarchy. Different decision makers lose their identity and they are very consistent. The methods implementing the aposterior methods focus on the final result, the final personal ranking of the alternatives of each decision maker, where the rankings have to be aggregated in one final ranking. These methods are the crosspoint of multicriteria analysis and voting methods. In voting there are multiple decision makers and multiple alternatives/candidates and the task is to sort them in a priority list. Multicriteria analysis methods provide the personal rankings of the decision makers and voting methods provide the aggregation of the rankings in one final ranking.

So, the development of Internet-enabled decision support systems (DSS), supporting group decisions, is very important in the emerging information society.

In this context the main goal of this paper is to propose new interactive methods for group solving of multiple criteria analysis problems, suitable for different kind of organisational structures.

The rest of the paper is organized as follows: in section 2 a classification of group decision support systems is made; in section 3 the group decision support system Group Multichoice is described and the results are summarized in section 4.

2 Classification of group decision support systems

Decision support systems are divided into two major classes – universal systems and problem-oriented systems.

Depending on the number of decision makers, the systems can be local, intranet and Internet-based. Local systems are installed on one computer and are used either by one DM, or (in group decision making) by a number of decision makers using the computer in turns. Intranet based systems are deployed in LAN environment, where every decision maker uses his/her own computer. Depending on the software architecture there can be a central server. The time for decision making/using the system is limited due to the use of telecommunication technologies for providing communication between the group participants. The minimum is a text chat, but audio or video conference lines are also recommended.

Internet based systems allow the team to be spread over a large geographic area. This systems has a central server used not only for relaying information but also for storing it, and that is what provides the opportunity for a decision making process extended over a longer periods of time. Every GDSS should provide two functions: communication and decision support.

3 Description of the *Group Multichoice* system

The system starts its existence as experimental research system and one of the goals is to check the hypothesis, that one system can implement methods from different classes, which allows among other things to separate the definition of the problem of its solving. As a result, the system interface is designed as a "wizard" – a sequence of steps where each step is a logical operation. Every stage of the work with the system corresponds to one or more windows in the

wizard. The DM is able to go forward or to go back in order to make some changes or to try another option.

Group Multichoice system operates in client or server mode. The client subsystem works in MS Windows environment and can be used independently for solving discrete multicriteria opitmisation problems. The client subsystem started its existence as an experimental research system for proving the hypothesis, that a DSS can implement methods from different classes. That is why the definition of the problem is separated from its solving and the process is split into four stages:

- problem definition
- method selection
- definition of method-specific information
- receiving and evaluating of final result

Implementing the user interface as "wizard" and allowing the user to go back and make a different choice is extremely useful when the system is used for training purposes. An additional benefit of separating the definition of the problem from its solving is providing options for solving a single problem with several different methods and comparing their strengths, weaknesses and results, as well as their suitability for the given problem. *Group Multichoice* uses its own binary format for the file saves and because of that the solving process can be interrupted and saved at any given point. One more advantage of the above mentioned separation is the possibility for implementation of additional methods with minimal changes in the code.

Group Multichoice offers dynamic context help. The user can get information for every element of the interface just by moving the mouse over it. The system operates in two languages – Bulgarian and English. The whole interface is translated and the language can be switched at every stage of working with the system. The translation module is designed in a way that makes adding new languages very easy. The system performs automatic software updates if Internet connection is available when it is started.

Solving the multicriteria problems is performed by means of four different methods - a weighting one (AHP) [2], two outranking ones (ELECTRE III [3], PROMETHEE II) and an interactive one (CBIM) [4] and the procedures for conversion of qualitative, ranging and weighting criteria into quantitative criteria.

When the process of solving new problem starts, the user is required to enter the goal of the problem, the parameters and the names of the criteria and the names of the alternatives. On the next steps of the wizard, the user enters the values of the alternatives in relation of every criterion and depending of the type of the criterion one of the following windows is shown.

After entering the values of the alternatives regarding every criterion, the user has to choose a method for solving the problem. After that window, corresponding with the chosen method is opened. The window of the AHP method facilitates user for the pairwise comparison of the criteria in order to calculate the relative importance of that criteria. After entering this data the built matrix "criteria X criteria" is shown to the user and it is used for finding their weights via their eigenvalues.

The user interfaces of the PROMETHEE and ELECTRE methods are

similar to each other as they are from one group and therefore similar additional information is required from the user. Figure 1 shows the window for PROMETHEE. On the left hand side a table with the values of the alternatives and their values regarding criteria is shown, and on the righthand side are the properties of the criteria. After selecting a criterion from the table, the user is expected to enter the values of its thresholds and the type of the function for pairwise comparison of the alternatives.

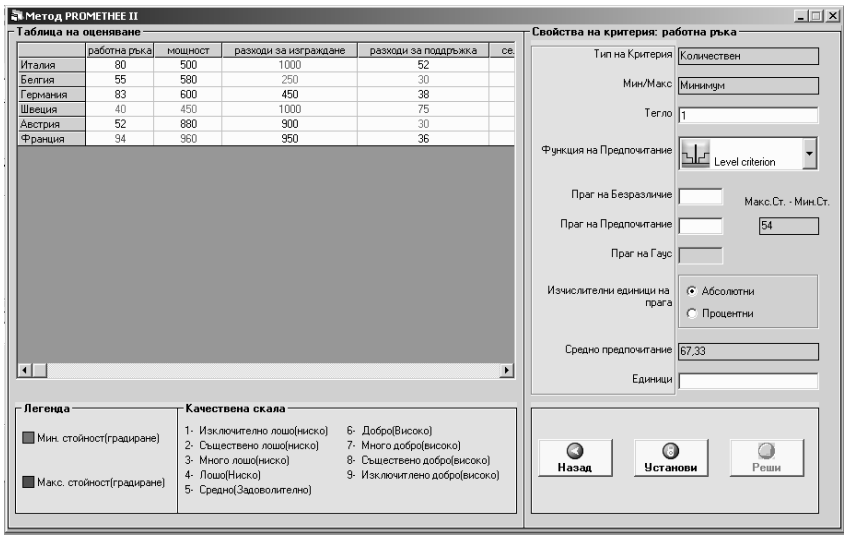

Fig. 1

The interactive method CBIM is split into two windows. In the first window the user defines aspiration levels, intervals and directions of change of the criteria. In the second window the currently inadmissible and currently preferred alternatives are marked in the list of all alternatives and the user can select the currently preferred or any other alternative as a starting point for the next iteration. When the user is satisfied with the current solution, the window with the final ranking is shown.

The server subsystem is written in Python and is platform-independent. Every decision making session has only one server and all clients are connected to this server. The leader/group facilitator works with the server. The capabilities for supporting group decisions are provided by five interactive methods, developed by the author[5] – GCBIM, GECBIM, BIMBEE 1, BIMBEE 2 [6] and GCBIM-NN. These methods cover the spectrum of different group types and decision styles [7]- individual consultative style, leaderless team, participative style, leaderless group and group consulting style.

4 Conclusions and Future Work

Group Multichoice is an experimental software system, supporting group decision making and solving multicriteria analysis problems. The system implements four methods for this class of problems and five methods for supporting group decision making. The group decision can be taken in autocratic

style with advisers or in a democratic style, when all participants are equal. The system allows network communication, provides user-friendly interface and extensive help information. Each decision maker is able to reach a final result using his/her preferred method.

Future work includes testing the system with different real-life scenarios, updating the user interface and encrypting the network communication.

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